

**INFLUENCE OF PEAK GROUND  
ACCELERATION AND SOIL TYPE ON SEISMIC  
DESIGN OF RC HOTEL BUILDING**

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**B. ENG (HONS.) CIVIL ENGINEERING**

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## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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## ABSTRAK

Pada bulan Jun 2015, Malaysia terkejut dengan magnitud 6.0 gempa bumi yang melanda Ranau, salah satu daerah di Sabah. Gempa bumi yang sederhana telah memecahkan rekod paling kuat pada tahun 1976, apabila gempa bumi berukuran 5.8 skala Richter melanda Lahad Datu, menyebabkan kerosakan berat terhadap harta dan keretakan ke bangunan. Walaupun Sabah berada di luar Lingkaran Api Pasifik, Pusat Penyelidikan dan Inovasi Universiti Malaysia Sabah mendapati kawasan di Kundasang, Ranau, Pitas, Lahad Datu dan Tawau berisiko terkena gempa bumi. Selepas mengalami gegaran, Malaysia mula menyedari tentang kepentingan reka bentuk seismik mengenai struktur bangunan. Walau bagaimanapun, akibat aplikasi reka bentuk seismik pada kos bahan perlu dipelajari terlebih dahulu. Berhubung dengan itu, kajian ini membincangkan reka bentuk seismik bangunan hotel konkrit bertetulang (RC) dengan pertimbangan magnitud yang berbeza dari pecutan tanah puncak (PGA) dan jenis tanah yang berlainan. Objektif utama kajian ini adalah untuk mengkaji pengaruh PGA terhadap jumlah pengukuhan keluli. Objektif kedua ialah menganalisis kesan jenis tanah pada jumlah pengukuhan keluli. Sepuluh model bangunan hotel dengan pertimbangan jenis PGA dan tanah yang berbeza dipertimbangkan, iaitu bangunan bukan seismik, Tanah Jenis B, Tanah Jenis D, Tanah Jenis E dengan PGA 0.04g, 0.10g, 0.16g. Untuk magnitud yang berbeza PGA, hasil menunjukkan bahawa perbezaan peratusan pengukuhan keluli yang diperlukan berbanding dengan reka bentuk bukan seismik untuk balok dan lajur keseluruhan bangunan telah meningkat daripada 14%, 48% kepada 153% untuk PGA bersamaan dengan 0.04g, 0.10 g, dan 0.16g masing-masing. Sedangkan bagi jenis tanah yang berbeza, hasil menunjukkan bahawa perbezaan peratusan pengukuhan keluli yang diperlukan berbanding dengan reka bentuk bukan seismik telah meningkat dari 79% hingga 153% dan dikurangkan kepada 93% untuk Tanah Jenis B, Tanah Jenis D dan Tanah Jenis E masing-masing. Akibatnya, magnitud PGA dan jenis struktur tanah memberi kesan besar kepada jumlah keseluruhan pengukuhan keluli yang diperlukan. Oleh itu, adalah penting untuk mempertimbangkan parameter ini dalam merekabentuk bangunan seismik.

## ABSTRACT

In June 2015, Malaysia was shocked by a 6.0 magnitude of earthquake that had struck Ranau, one of the districts in Sabah. The moderate earthquake has broken the strongest record set in 1976, when an earthquake measuring 5.8 on the Richter scale struck Lahad Datu, causing heavy damage to property and cracks to building. Although Sabah is outside the Pacific Ring of Fire, the Centre of Research and Innovation of Universiti Malaysia Sabah, found areas in Kundasang, Ranau, Pitas, Lahad Datu and Tawau at risk of earthquakes. After been experiencing the tremors, Malaysian start to aware on the importance of seismic design on building structure. However, the consequence of seismic design application on cost of materials need to be studied beforehand. In relation to that, this study discusses on the seismic design of reinforced concrete (RC) hotel building with consideration of different magnitude of peak ground acceleration (PGA) and different soil type. The first objective of this study is to study the influence of PGA on the amount of steel reinforcement. The second objective is to analyse the effect of soil type on the amount of steel reinforcement. Ten models of hotel building with consideration of different PGA and soil type are considered, namely, non-seismic building, Soil Type B, Soil Type D, Soil Type E with PGA of 0.04g, 0.10g, 0.16g. For different magnitude of PGA, the results shows that the percentage difference of steel reinforcement required compared to non-seismic design for beam and column of the whole building had increased from 14%, 48% to 153% for PGA equals to 0.04g, 0.10g, and 0.16g respectively. While for different soil type, the results shows that the percentage difference of steel reinforcement required compared to non-seismic design had increased from 79% to 153% and reduced to 93% for Soil Type B, Soil Type D and Soil Type E respectively. Consequently, magnitude of PGA and soil type of structure give major effect to overall amount of steel reinforcement required. Thus, it is important to consider these parameter in designing a seismic building.

## TABLE OF CONTENT

<b>DECLARATION</b>	
<b>TITLE PAGE</b>	
<b>ACKNOWLEDGEMENTS</b>	<b>ii</b>
<b>ABSTRAK</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>TABLE OF CONTENT</b>	<b>v</b>
<b>LIST OF TABLES</b>	<b>ix</b>
<b>LIST OF FIGURES</b>	<b>x</b>
<b>LIST OF SYMBOLS</b>	<b>xii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xiii</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>14</b>
1.1 Background	14
1.2 Problem Statement	17
1.3 Objectives	18
1.4 Scope of Work	18
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>19</b>
2.1 Introduction	19
2.2 Effect of Sumatra Fault	19
2.3 Seismic Hazard Assessment	21
2.4 Seismic Design Study	23
2.5 Peak Ground Acceleration	25

2.6	Summary	26
<b>CHAPTER 3 METHODOLOGY</b>		<b>27</b>
3.1	Introduction	27
3.2	Research Methodology Flow Chart	27
3.3	Phase 1 – Generate Basic Model	28
3.4	Phase 2 – Seismic Design and Analysis	30
3.4.1	Seismic Base Shear Force, $F_b$	33
3.4.2	Design Response Spectrum Analysis	33
3.4.3	Design Ground Acceleration	34
3.4.4	Lateral Load Distribution	37
3.4.5	Seismic Design of Beam	37
3.4.6	Seismic Design of Column	39
3.5	Phase 3 – Taking Off	40
<b>CHAPTER 4 RESULTS AND DISCUSSION</b>		<b>41</b>
4.1	Introduction	41
4.2	Design Response Spectrum and Base Shear Force	41
4.3	Influence of PGA and Soil Type on the concrete volume required	44
4.4	Influence of Soil Type on the Amount of Steel Reinforcement Required	45
4.4.1	Influence of soil type on the amount of steel used for beam reinforcement	46
4.4.2	Influence of soil type on the amount of steel used for column reinforcement	47
4.4.3	Influence of soil type on the amount of steel used for total reinforcement	48
4.5	Influence of PGA magnitude on the amount of steel reinforcement required	49



4.5.1	Influence of PGA magnitude on the amount of steel used for beam reinforcement	49
4.5.2	Influence of PGA magnitude on the amount of steel used for column reinforcement	50
4.5.3	Influence of PGA magnitude on the amount of steel used for total reinforcement	52
4.6	Total weight of steel reinforcement per 1m <sup>3</sup> concrete normalised to non-seismic model	53
4.6.1	Total weight of steel reinforcement per 1m <sup>3</sup> concrete normalised to non-seismic model for Soil Type B	53
4.6.2	Total weight of steel reinforcement per 1m <sup>3</sup> concrete normalised to non-seismic model for Soil Type D	54
4.6.3	Total weight of steel reinforcement per 1m <sup>3</sup> concrete normalised to non-seismic model for Soil Type E	54
4.7	Estimation of total cost of material required	55
4.7.1	Estimation of total cost of material used for Soil Type B	55
4.7.2	Estimation of total cost of material used for Soil Type D	56
4.7.3	Estimation of total cost of material used for Soil Type E	57
	<b>CHAPTER 5 CONCLUSION</b>	<b>59</b>
5.1	Conclusion	59
5.2	Future Recommendation	61
	<b>REFERENCES</b>	<b>62</b>
	<b>APPENDIX A</b>	<b>65</b>
	<b>APPENDIX B</b>	<b>67</b>
	<b>APPENDIX C</b>	<b>68</b>
	<b>APPENDIX D</b>	<b>70</b>



## LIST OF TABLES

Table 3.1	Dimension of the members in the models	28
Table 3.2	Weight of materials	30
Table 3.3	Categories of building use	31
Table 3.4	Imposed loads on floors, balconies and stairs in buildings	32
Table 3.5	Categorization of roofs	32
Table 3.6	Imposed loads on roofs of category H	32
Table 3.7	Values of parameters describing the recommended Type 1 elastic response spectra	34
Table 3.8	Importance classes for buildings	35
Table 3.9	All models of hotel building	36
Table 4.1	Base shear force and design response spectrum value for all models	43
Table 4.2	Parameter for beam reinforcement with different soil type	46
Table 4.3	Parameter for column reinforcement with different soil type	47
Table 4.4	Parameter for beam reinforcement with different moment magnitude of PGA	50
Table 4.5	Parameter for column reinforcement with different moment magnitude of PGA	51

## LIST OF FIGURES

Figure 1.1	Location of magnitude 6.0 Ranau earthquake in Sabah	15
Figure 1.2	Earthquake hazard zones in Malaysia	15
Figure 1.3	Earthquake-prone region in Malaysia	16
Figure 1.4	Location of MMD seismic stations across Peninsular Malaysia and the ground motion values recorded for the period 2004–2016	17
Figure 2.1	Location of earthquake and epicentre distance from Penang and Kuala Lumpur	21
Figure 2.2	Seismic Hazard Maps for Peninsular and East Malaysia	22
Figure 2.3	Location of seismological stations in Malaysia	22
Figure 2.4	PGA value for fault zone in Peninsular Malaysia	26
Figure 3.1	Summary of research methodology	28
Figure 3.2	Side view of hotel building frame	29
Figure 3.3	Plan view of hotel building	29
Figure 3.4	3D model of the building generated from Tekla Structural Design software	36
Figure 3.5	Flow chart of beam design according to Eurocode 8	38
Figure 3.6	Column seismic design flow based on Eurocode 8	39
Figure 4.1	Design Response Spectrum with different magnitude of PGA	42
Figure 4.2	Design Response Spectrum with different soil type	43
Figure 4.3	Total concrete volume of beam for whole building	44
Figure 4.4	Total concrete volume of column for whole building	45
Figure 4.5	Total concrete volume of all for whole building	45
Figure 4.6	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for beam reinforcement	46
Figure 4.7	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for column reinforcement	47
Figure 4.8	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for column reinforcement	48
Figure 4.9	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for beam reinforcement	49
Figure 4.10	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for column reinforcement	51
Figure 4.11	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete for beam reinforcement	52
Figure 4.12	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete normalised for Soil Type B	53

Figure 4.13	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete normalised for Soil Type D	54
Figure 4.14	Total weight of steel reinforcement for 1m <sup>3</sup> of concrete normalised for Soil Type E	55
Figure 4.15	Estimation of cost material used for Soil Type B	56
Figure 4.16	Estimation of cost material used for Soil Type D	57
Figure 4.17	Estimation of cost material used for Soil Type E	58

## LIST OF SYMBOLS

$\alpha_g$	Design ground acceleration
$\alpha_{gR}$	Reference peak ground acceleration
$A_{S_{prov}}$	Total area of steel provided
$A_{S_{req}}$	Total area of steel required
$d_{bL}$	Diameter of longitudinal bar
$d_{bw}$	Diameter of shear or confinement bar
$F_b$	Base shear force
$f_{cd}$	Design value of concrete compressive strength
$f_{ck}$	Characteristic cylinder strength of concrete
$F_i$	Lateral load on storey
$f_y$	Yield strength of reinforcement
$g$	Acceleration due to gravity, $m/s^2$
$G_k$	Dead load
$H$	Storey height
$M$	Bending moment
$m_i$	Mass of storey $i$
$M_{Rb}$	Design moment resistance of beam
$M_{Rc}$	Design moment resistance of column
$M_w$	Magnitude of earthquake intensity
$N$	Number of storey
$q$	Behaviour factor
$Q_k$	Live load
$S$	Soil factor
$S_d(T_1)$	Ordinate of the design spectrum at period
$T_1$	Fundamental period of vibration
$T_B$	Lower limit of the period of the constant spectral acceleration
$T_C$	Lower limit of the period of the constant spectral acceleration
$T_D$	Beginning of the constant displacement response range of the spectrum
$V$	Beginning of the constant displacement response range of the spectrum
$\lambda$	Correction factor
$\gamma_1$	Importance factor

## **LIST OF ABBREVIATIONS**

DCH	Ductility class high
DCL	Ductility class low
DCM	Ductility class medium
JKR	Jabatan Kerja Raya
MMD	Malaysian Meteorological Department
PGA	Peak ground acceleration
RC	Reinforced concrete

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Earthquake is one of the natural disaster which resulting from natural processes of the earth. It also can be called “seismic tremor” which describes as natural phenomenon that suddenly strikes an area causing some damage that varies according to the intensity of the quake and local geological condition. Earthquake can caused the ground shakes and create sudden ground movement that could make any building become unstable.

According to McClure et al. (2011), when an earthquake occurs on a fault, it will releases portion of energy that has been stored in the earth’s crust. Hence, this will makes it less likely that additional earthquakes will occur on this same fault until additional stress can accumulate. Small magnitude earthquakes can liberate small amount of energy and stress, vice versa with large-magnitude earthquakes. However, small magnitude earthquake energy released can be accumulate in just a few of years to decades. While, it may took several hundred years and perhaps several thousand years for energy released by large magnitude earthquake to accumulate.

In year 2015, a 6.0 moment magnitude ( $M_w$ ) earthquake had struck on the foot of Mount Kinabalu near the highland town of Kundasang in the district of Ranau, Sabah. Since the 1976 earthquake at Lahad Datu happened, this earthquake give the highest impact to Malaysia which the tremor were last to 30 seconds. In addition, the tremors were also felt all over Sabah as far afield as Labuan, Miri and Brunei. This incident jolted the Malaysia’s Mount Kinabalu caused fatality of public 11 hikers and another 8 hikers was missing. It also damaged the Donkey’s Ear, the pride symbol of Mount Kinabalu. This earthquake also felt by West Coast Sabah people included of Tambunan, Tuaran, Kota Kinabalu, and Kota Belud. Weak aftershocks occurred about 47 times



around  $M_w$  2.2 to  $M_w$  3.3. The quake alerting the Malaysian engineers about the earthquake awareness on building his incident had cause physical damaged at building and also cause injuries and death to people. (Tongkul, 2016)

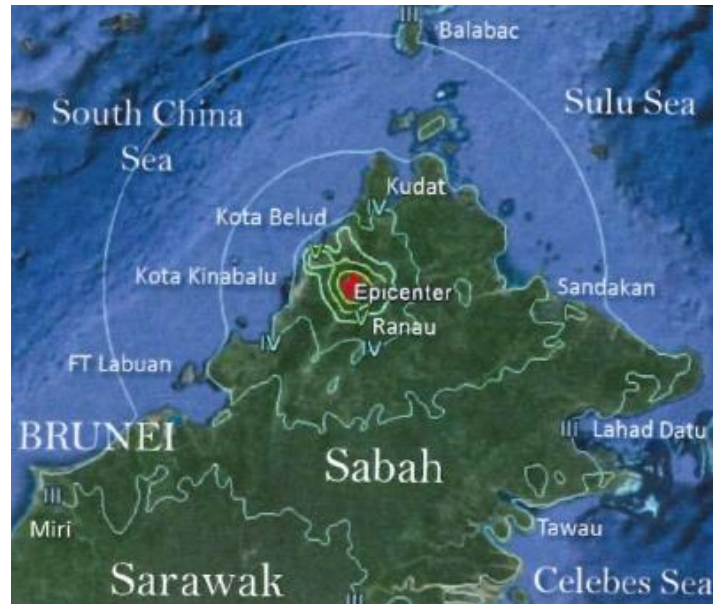


Figure 1.1 Location of magnitude 6.0 Ranau earthquake in Sabah (Tongkul, 2016)

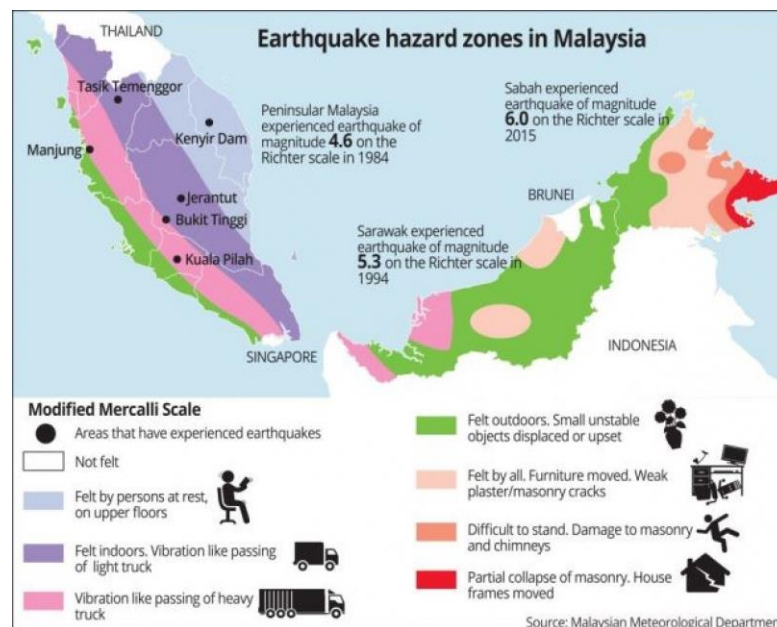


Figure 1.2 Earthquake hazard zones in Malaysia (*Malaysian Meteorological Department, MMD*)

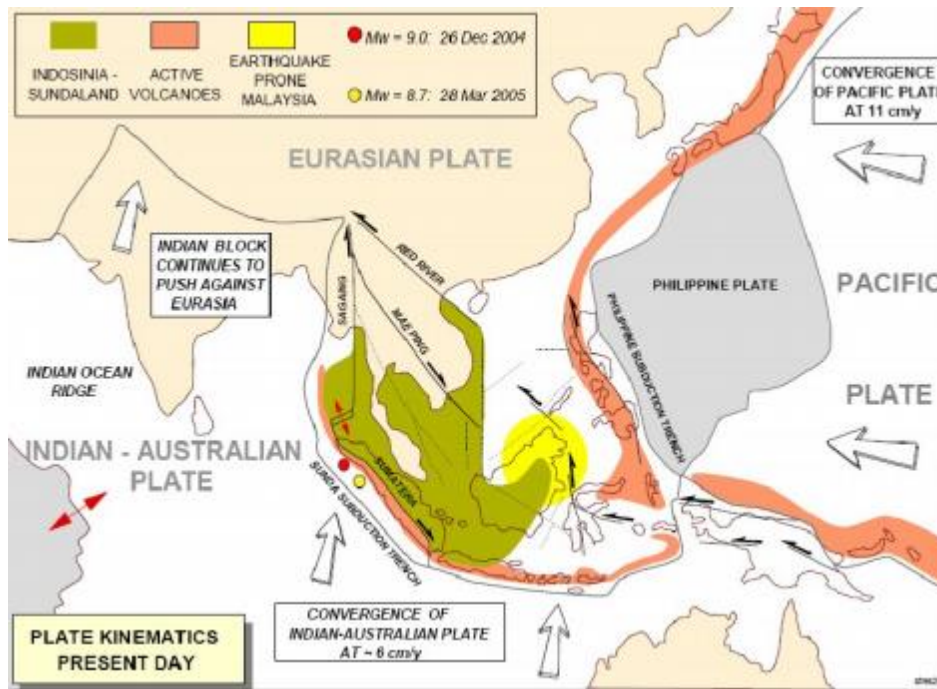


Figure 1.3 Earthquake-prone region in Malaysia (Tija, 2010)

Most buildings in Malaysia had been designed according to BS8110 since Malaysia is not located in active seismic fault zones. However, after been experiencing the tremors, Malaysian start to aware on the importance of seismic design on building structure. (Adiyanto & Majid, 2014). According to Ahmad Jani (2018), damage potential must not be neglected since strong impact of earthquake from neighbouring countries could create considerably ground motion over Peninsular Malaysia even though Malaysia has low seismic risk.

According to Adiyanto (2014), there are several factors that could affect the seismic design structure. For example, location of site, type of soil, Peak Ground Acceleration (PGA), materials and structure type, class ductility, stiffness and behaviour factor,  $q$ . This study covered on the influence of different magnitude of PGA and the soil type to seismic deign of reinforced concrete (RC) hotel building. These two parameters are significant in specifying earthquake actions for seismic design. The amount of steel required also could be determined through this study. To sum up, in reducing the damages in a structure, this study will determine the effect of different PGA and soil type to seismic design structure.

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